(January 10, 2022)

Composite Arch System

Design

The CAS design, Superstructure and foundation, shall conform to Section 6-20.3(1), and the following:

The CAS shall be designed in accordance with the AASHTO LRFD Bridge Design Specifications, the AASHTO LRFD Guide Specifications for Design of Concrete-Filled FRP Tubes for Flexural and Axial Members, the ASCE Pre-Standard for LRFD of Pultruded FRP Structures, and other applicable specifications.

The CAS shall be designed by the supplier on a project-specific basis by a licensed professional engineer, with design and load rating calculations and fabrication shop drawing Working Drawings provided to the Contractor.

Submittals

Submittals for CAS Superstructure and foundation shall conform to Section 6-20.3(2).

Foundation

The CAS foundation shall be constructed in accordance with Sections 6-20.3(5) and 6-20.3(6).

Fabrication

The CAS structural components shall be fabricated, either by the supplier or an independent fabricator licensed by the supplier, in accordance with Section 6-20.3(7) and the following:

Fabrication Quality Control/Quality Assurance

FRP composite hollow tubes shall be fabricated in accordance with the supplier's QC/QA plan and standard operating procedures. The portions of the QC/QA plan and procedures which do not contain trade secret material will be submitted to the Contracting Agency for review upon Engineer's request prior to beginning fabrication.

The FRP laminate comprising the tube shell shall be tested for tensile strength. Test result documentation of the mechanical properties and the required design values shall be submitted as a Type 1 Working Drawing.

A minimum of five test specimens shall be obtained from each FRP composite hollow tube. A minimum of two specimens per tube shall be tested. If the mean of the two tests from any one tube fails to meet or exceed the required design value, then at least three more specimens from the corresponding tube shall be tested. If the mean of the three additional specimens does not meet or exceed the design value, the tube will be rejected and replaced. All test results shall be submitted as a Type 1 Working Drawing prior to placing and assembling the tubes.

FRP Composite Hollow Tube Fabrication

The FRP composite hollow tubes may be fabricated as specified below using a closed mold vacuum assisted resin transfer method (VARTM) of composite manufacturing:

Reinforcement Storage and Preparation

Fabrics shall be stored in a clean, dry environment in the original packaging. They shall be protected from water, dirt, grease, grinding dust, and other foreign matter. The fabrics shall be cut on a clean cutting surface, free of any deleterious material that may adhere to the fabrics prior to layup. Longitudinal fabric shall not be spliced. Hoop reinforcement may be spliced.

Chemicals

Vinyl ester resins and other chemicals necessary for catalyzing the infusion matrix shall be stored in accordance with the manufacturer's recommendations.

Vacuum Assisted Resin Transfer

Prior to vacuum infusion of the vinyl ester matrix, the fabricator shall thoroughly seal the tooling and demonstrate that the sealed tooling can obtain a minimum workable vacuum pressure and a drop test. Chemical additives and catalysts to be combined with the vinyl ester resin shall be measured by weight, or the corresponding volume, based on the batch weight of the vinyl ester resin. The fabricator shall maintain documentation of the promotion rates and the actual amount of catalyst used for each infusion.

The infusion tank shall be charged with a sufficient amount of resin at all times to prevent air bubbles from entering the infusion ports in the tooling. Once resin is introduced into the tooling, the infusion process shall continue uninterrupted until it has been demonstrated that all evacuation ports have a surplus of resin flowing past the finished surface of the tooling and that no less than the predicted volume of resin has been introduced into the tool.

Post Processing

Once the laminate has been allowed to harden, the FRP composite hollow tubes shall be removed from the form with care so as not to induce stresses into the curing laminate. The laminate shall reach a minimum Barcol hardness value of 35 prior to removing the tubes from the form.

Tolerances

The finished FRP composite hollow tubes shall conform to the dimensions set forth in the accepted Type 2 Working Drawing fabrication shop drawings of Section 6-20.3(2). The diameter shall not vary in any one section by more than one-percent of the dimension given in the fabrication shop drawings. The tubes shall be checked for shape variations. No tube may vary from the shape specified in the fabrication shop drawings, expect for diameter, by more than 2-inches or one-percent of the dimension, whichever is smaller.

Composite Arch System Placement and Assembly

The CAS structural components shall be erected in accordance with Section 6-20.3(8) and the following:

Assignment of Responsibility

The supplier shall furnish the Contractor the FRP composite hollow tubes, FRP deck panels, stainless steel fasteners, and the structural adhesive at the project site on the date requested by the Contractor.

The Contractor is responsible for the complete installation of the FRP composite hollow tubes including but not limited to unloading and storing the tubes at the project site, erecting and setting the tubes into the reinforced concrete foundation, filling the tubes with ESCC, inspecting the filled tubes for voids, and filling such voids if any are found.

After receiving the accepted fabrication shop drawings, the Contractor shall notify the fabricator to fabricate and deliver the FRP composite hollow tubes, FRP deck panels, stainless steel fasteners, and the structural adhesive to the project site.

Handling and Storage at the Project Site

Care shall be taken when handling the FRP composite hollow tubes such that no damage is caused to the unfilled tubes. When moved or placed by hand, tubes shall be stabilized to prevent tipping over. When moved by hoist, straps shall provide at least 2 inches of padded contact area.

The Contractor is responsible for receiving, unloading, and storing the FRP deck panels. All FRP deck panels shall be handled with care and protected from cuts, scratches, and abrasions. FRP deck panels shall be stored on blocking off the ground and kept clean and dry. Damaged panels shall be replaced at no additional expense to the Contracting Agency.

FRP Tube and FRP Panel Placement and Assembly

The Contractor is advised that the FRP composite hollow tubes have some flexibility prior to filling with ESCC, and tubes out of tolerance without any outside loading may be brought into tolerance with a small force applied at each end. All tubes shall be clearly marked by the fabricator in accordance with the designation in the fabrication shop drawings.

The FRP composite hollow tubes shall be erected in a vertical position and FRP deck panels installed prior to filling the tubes with ESCC. The maximum allowable variation of installed tubes shall be ± 1/2-inch in-plane and out-of-plane. The FRP deck panels shall be installed over the tubes after the tubes are erected and aligned. The tubes shall be set into the reinforced concrete foundation as shown in the Plans. Care shall be taken when placing the foundation and vibrating around the base of the tubes as to not damage or displace the tubes.

FRP deck panels shall be installed as shown in the Plans using fasteners provided. The first row of FRP deck panels shall be installed on each side prior to casting the foundation stem wall. The remaining FRP deck panels shall be

installed after the foundation stem wall has been cast and prior to filling the FRP composite hollow tubes with ESCC.

Adhesive provided shall be used in accordance with the manufacturer's recommendations to seal the longitudinal joint between the panels. FRP deck panels shall be installed starting at the bottom at both ends of the FRP composite hollow tubes and proceeding to the apex. The Contractor shall assure that the starter panels are placed as shown in the Plans to a level line. A closure plate is provided at the apex to be field-trimmed to fit and attached after the tubes are filled with ESCC.

Once the foundation has achieved 2000 psi minimum concrete compressive strength, the erected FRP composite hollow tubes shall be filled with ESCC.

Placing ESCC Tube Fill

ESCC will be accepted as a self-consolidating concrete in accordance with Section 6-02.3(5).

ESCC shall be placed in accordance with Section 6-02.3(6) and the following:

All FRP composite hollow tubes shall be filled with ESCC under the observation of the Engineer. The tubes shall be filled in one continuous operation. Vibration may be necessary for shallow rise tubes and such use of vibration will be determined by the Engineer. The tubes shall be filled through the fill holes that are field drilled by the Contractor to the size and locations shown in the fabrication shop drawings.

ESCC placement shall be accomplished using a method capable of directing the ESCC into the 3-inch fill hole and regulating placement speed to prevent voids. Acceptable methods include the use of a boom type pump truck, a trailer pump, or a standard concrete bucket. The Contractor shall have an alternative method available in the event of an equipment malfunction.

All FRP composite hollow tubes shall undergo auditory tap testing after ESCC placement to ensure complete filling of tubes. In the event that voids are discovered, they shall be injected with grout conforming to Section 9-20.3(2) for large voids or epoxy bonding agent conforming to Section 9-26.1 for small voids. The maximum permitted hole size for grout injection is 3/4-inch. The supplier shall be provided 72-hour minimum notice and offered the opportunity to be present for the filling of the tubes and tap testing.

Backfilling the Assembled Composite Arch System

The CAS shall be backfilled in accordance with Section 6-20.3(9) and the following:

ESCC fill in the FRP composite hollow tubes shall reach a minimum compressive strength of 3000 psi prior to any backfilling or compaction activities on the Structure other than headwall connection work.

Select gravel backfill shall extend to the lines and grades shown in the Plans and shall be placed in accordance with Section 2-09.3(1)E and as follows:

Backfill shall be placed in maximum 6-inch lifts with each layer compacted to 95-percent of the maximum density determined by the Compaction Control Test in accordance with Section 2-03.3(14)D. Compaction within 4-feet of the Structure shall be accomplished with hand compactors only. Vibratory rollers may be used outside of this zone and above the Structure provided there is at least 24-inches of compacted cover above the Structure.

All backfill shall be carefully placed to avoid damage to the Structure.

Lightweight equipment of an operating weight less than 12-tons may be operated over the Structure provided there is at least 12-inches of cover. Construction equipment of an operating weight 12-tons or greater may be used after 24-inches of compacted backfill has been placed over the Structure. In no case may the loading exceed the AASHTO design loading HL-93 without the Engineer's written permission.

Backfill shall be placed in lifts such that at no time will the elevation difference exceed 24-inches between opposite sides of the Structure.